Distributed Air-Ground Traffic Management Research

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Advanced Air Transportation Technologies Project

- Goal
  - In alliance with the FAA, enable the next generation of increases in efficiency, flexibility, capacity, and safety of aircraft operations within the US and global airspace system.
- Focus
  - Develop human-centered automation to assist air traffic management in short and intermediate term decision making between pilots, controllers, and dispatchers.

Program Benefit

National Airspace System Effectiveness

Safety

Improve Controller/pilot

- *Situation awareness*
- *Workload*

Predictability

Reduce time variance for

- *Departure*
- *En Route*
- *Landing*
- *Taxi*

Flexibility

Remove restrictions and Facilitate

- *User preferred routes*
- *National Route Program*
- *Inter-facility operations*
- *ATC/AOC/Flight Deck collaborative decisions*

Capacity

Increase Traffic Flow

- *airport/terminal airspace*
- *constrained en route sectors*
- *unconstrained airspace*

Efficiency

Optimize Personnel & Equipment Utilization

- *Honor user preferences*
- *Fewer advisories*
- *Flight Management System compatible clearance and procedures*

Improved Service

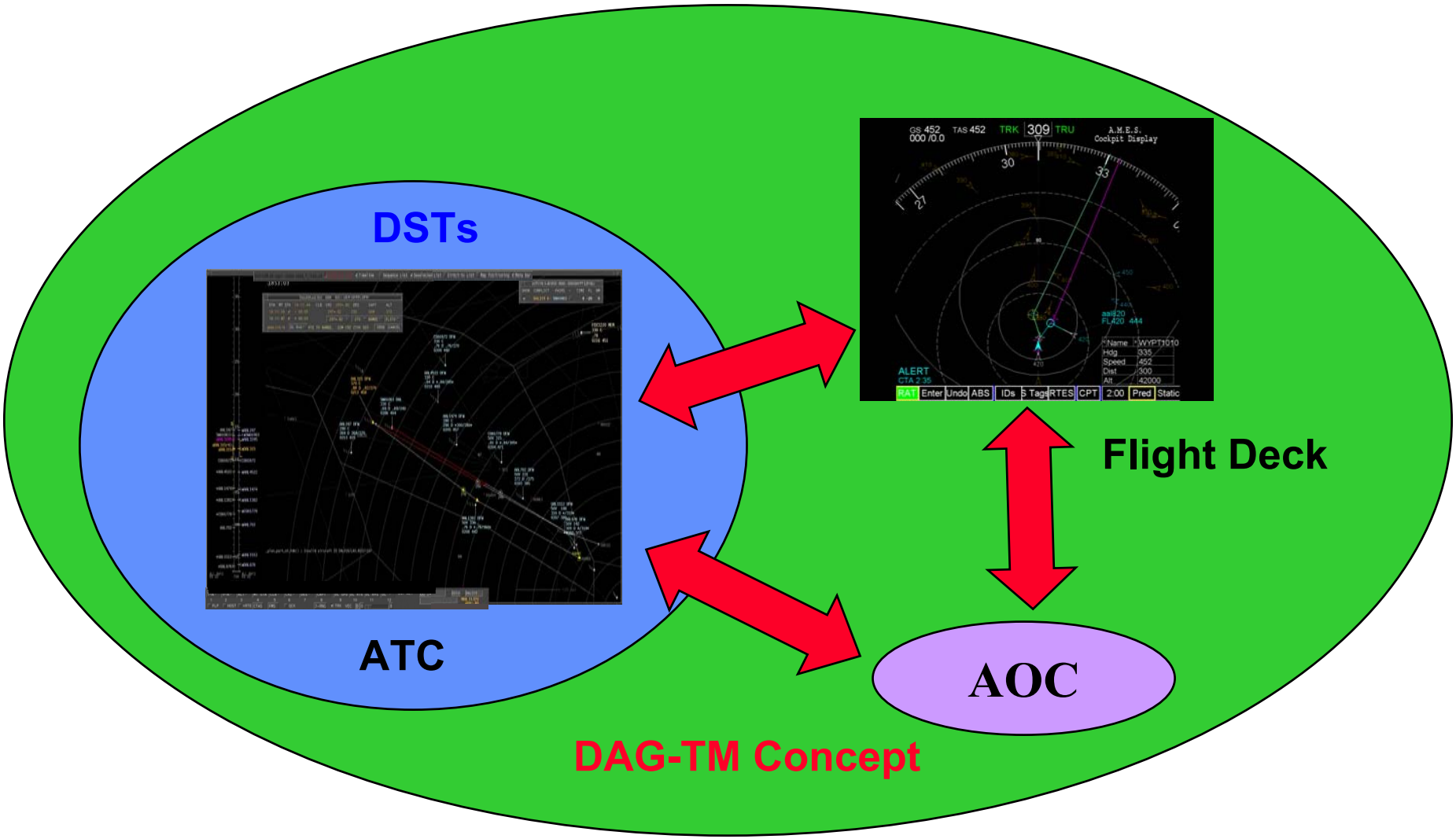
Reduced Energy/Emissions

Improved Use of Capital Investment
-crews/controllers
-aircraft/airport

Focus Areas

- Develop en route and terminal decision support tools for FAA Free Flight Phases 1 and 2
  - Enhance capabilities of present air traffic system
  - Deliver CTAS decision support tools to the FAA
- Distributed Air-Ground Traffic Management (DAG-TM) Research
  - Free Flight concept exploration
  - Evaluate feasibility of making major changes to current system and procedures
  - Deliver tested concepts to the FAA

CTAS Tools and DAG-TM



DAG-TM Definition

- Distributed Air-Ground Traffic Management is the Free Flight part of AATT
- In DAG-TM flight crews, air traffic service providers, and aeronautical operational control personnel use distributed decision making to:
  - Enable user preferences/flexibility
  - Increase system capacity
  - Meet air traffic management requirements
- NASA will investigate the feasibility of DAG-TM concepts during the next four years
  - Using NASA and FAA laboratory resources

Over-arching

Gate-to-Gate:
- CE-0 Data Exchange

Pre-flight

Pre-flight Planning:
- CE-1 User optimization for Constraints

Flight Operations

Surface Departure:
- CE-2 Intelligent [Taxi] routing

Terminal Departure:
- CE-3 Free Maneuvering for Separation
- CE-4 Trajectory Negotiation for Separation

En route: (Separation and local-TFM Conformance)
- CE-5 (a/b) Free Maneuvering
- CE-6 (a/b) Trajectory Negotiation

En route: (local-TFM)
- CE-7 Collaboration for SUA/Wx/Complexity

En route / Terminal: (local-TFM)
- CE-8 Collaboration for Arrival Metering

Terminal Arrival:
- CE-9 Free Maneuvering Around Weather
- CE-10 Trajectory Up link [to avoid] Weather

Terminal Arrival:
- CE-11 Self Spacing for Accurate Merge
- CE-12 Trajectory Exchange for Accurate Merge

Terminal Approach:
- CE-13 Closely Spaced Approaches

Surface Arrival:
- CE-14 Intelligent [Taxi] Routing

TFM = Traffic Flow Management

DAG-TM Concept Elements

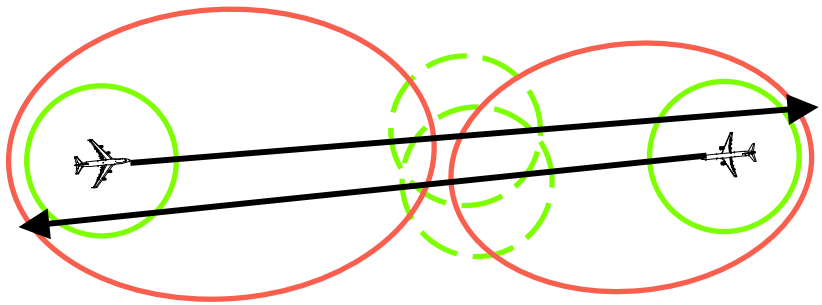
- Four CEs are being pursued:
  - CE-5: Free Maneuvering for User-preferred Separation Assurance and Local traffic flow management (TFM) Conformance
  - CE-6: Trajectory Negotiation for User-preferred Separation Assurance and Local TFM Conformance
  - CE-7: Collaboration for Mitigating Local TFM Constraints due to Weather, Special Use Airspace, and Complexity
  - CE-11: Self-spacing for Merging and In-trail Separation

CE-5:
Free Maneuvering for User-preferred Separation Assurance and Local TFM Conformance

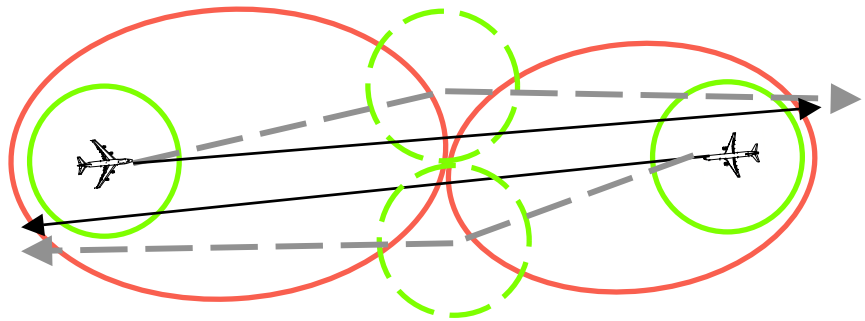
- **Problem:**
  - **Potential traffic separation conflicts often cause ATSP-issued deviations that are excessive or not preferred by users**
- **Solution:**
  - **Air: Cockpit Display of Traffic Information (CDTI)-equipped aircraft maneuver freely for separation assurance**
  - **Ground: ATSP monitors separation (with complementary ground-based tools) and provides separation assurance for non-equipped aircraft**

Free Maneuvering

Conflict Prediction: Protected Zones Predicted to Merge



Conflict Resolution: Cooperative Solution



Nominal Trajectory

Alert Zone

Protected Zone

Proposed Resolution

CE 6:
Trajectory Negotiation for User-preferred Separation Assurance and Local TFM Conformance

- **Problem:**
  - **Potential traffic separation conflicts often cause ATSP-issued deviations that are excessive or not preferred by users**
- **Solution:**
  - **User and ATSP negotiate for efficient resolution of conflicts**
  - **User-ATSP data exchange (intent, winds) for improved trajectory prediction**
  - **ATSP uses enhanced DSTs with conflict detection & resolution capabilities**

Trajectory Negotiation

Flight Deck

Aircraft Down links:
- Current state
- Trajectory intent
- Pilot preferences/constraints

AOC Up links:
- Airline preferences
- Key user data

ATSP Up links:
- Winds on path
- Trajectory constraints
- Relevant Flight & Traffic Information

Airline Operational Control

Air Traffic Control

AOC Ground links:
- Airline preferences
- Key flight data

ATSP Ground links:
- Relevant NAS state information

CE 7:
Collaboration for Mitigating Local TFM Constraints due to Weather, SUA, and Complexity

- **Problem:**
  - **ATSP cannot accommodate many trajectory change requests due to workload and ATSP-issued clearances are often not preferred by users (AOC or flight deck)**
- **Solution:**
  - **User and ATSP negotiate for user-preferred trajectory changes:**
    - **User formulates preferred trajectory changes, based on the latest weather, special use airspace, and local TFM constraints and transmits it to the ATSP**
    - **ATSP evaluates trajectory change request for approval**

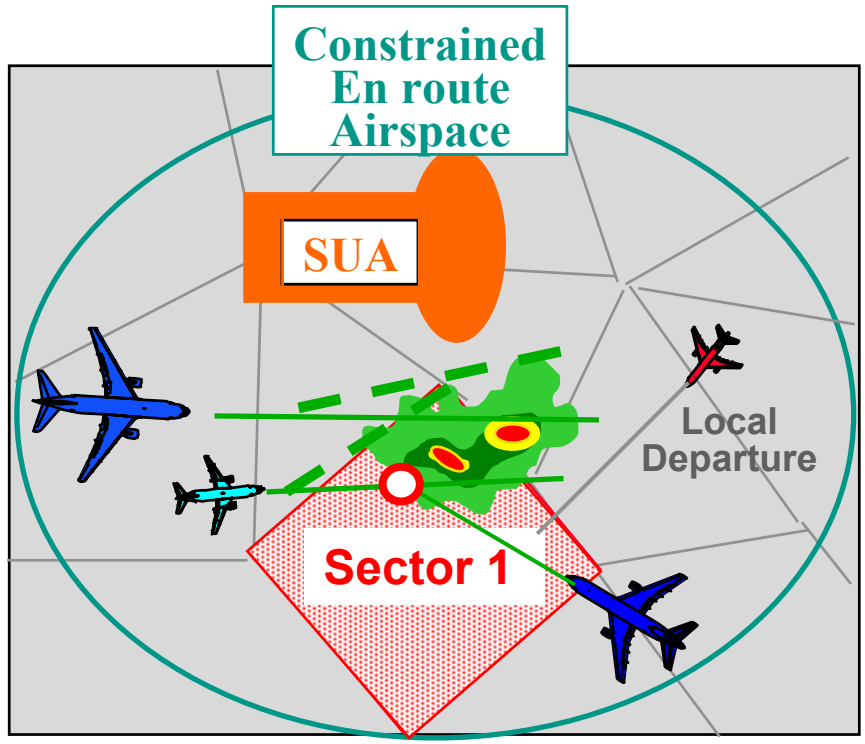
Collaboration for Wx, SUA, and Complexity Constraints

Congested Airspace
Airspace / sector complexity (dynamic density) is predicted to exceed acceptable levels

Planned Path (airborne)

Planned Path (pre-departure)

Predicted Conflict

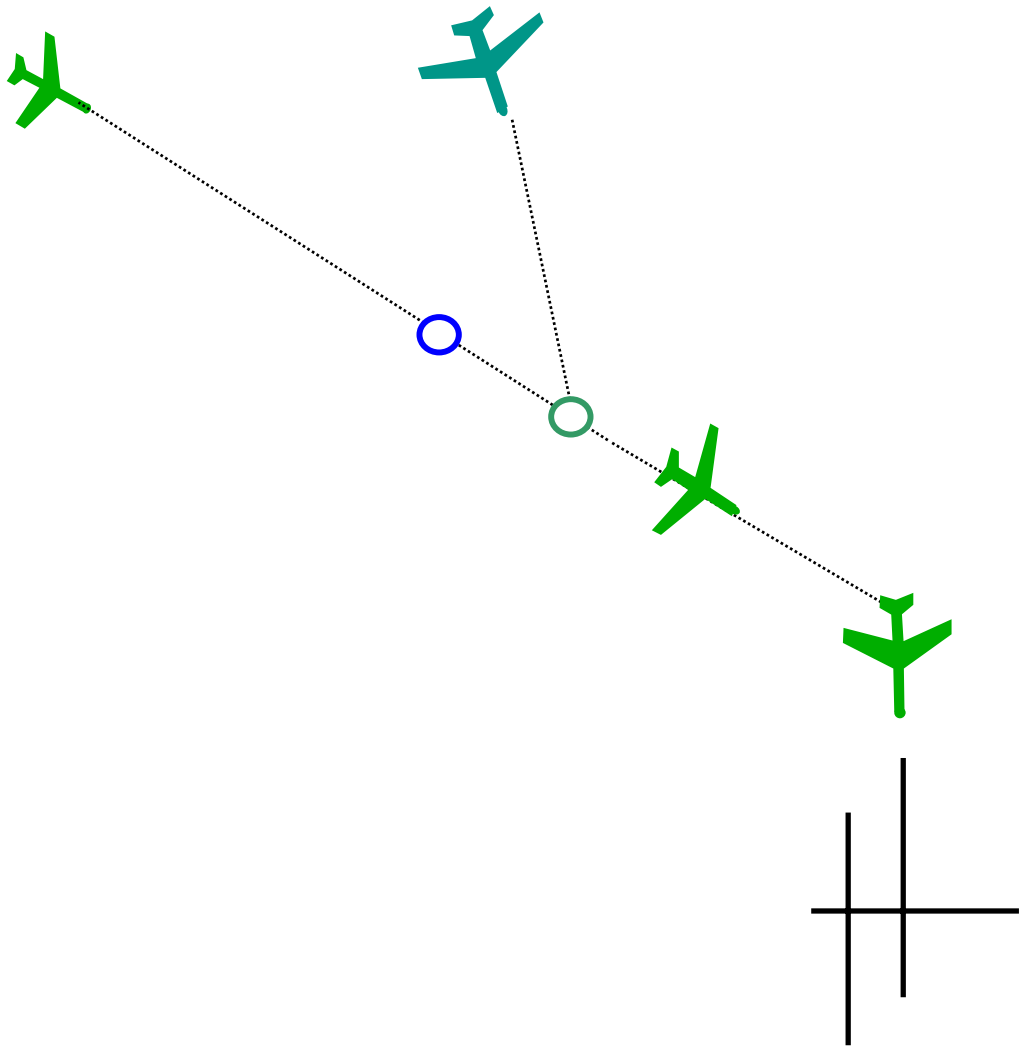


En route Air Route Traffic Control Center

CE 11:
Self-Spacing for Merging and In-trail Separation

- **Problem:**
  - **Excessive spacing buffers on final approach reduce arrival throughput and airport capacity**
- **Solution:**
  - **CDTI-equipped aircraft are cleared to maintain separation relative to a leading aircraft:**
    - **Flight deck displays and guidance for:**
      - **Self-spacing and merging**
      - **Fine tuning of fixed-time spacing**
  - **ATSP displays & procedures for shared separation responsibility**

Terminal Area Self Spacing



Potential DAG-TM Benefits

- Increased user efficiency and safety via improved conflict detection & resolution
- Increased user flexibility/efficiency (preferred trajectories)
- Reduced voice communications
- Reduction in ATSP workload for maintaining traffic separation
- Increased user flexibility/efficiency in the presence of dynamic en route constraints
- Increased arrival throughput
- Enhanced ATSP & pilot shared understanding of traffic management plan

Research Plans

- Develop and test decision support tools
- Three years of DAG-TM research
  - Develop and clarify concepts
  - Involve users (pilots, controllers, and dispatchers)
  - Conduct laboratory demonstrations of concepts
- Goal is to evaluate feasibility and potential benefits
- Deliver information and prototypes to the FAA by 2004

NASA Human Factors

- Developing tools for FAA Free Flight Phases 1 and 2
  - User interface design
  - Prototyping
  - Evaluations in laboratory and at sites
- DAG-TM - Far Term Free Flight
  - Concept development
  - User interface design
  - Procedures development
  - Evaluations